PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:

see form PCT/ISA/220

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/IB2005/050923	16.03.2005	26.03.2004

International Patent Classification (IPC) or both national classification and IPC
H01L27/24, H01L45/00, G11C11/56

Applicant
KONINKLIJKE PHILIPS ELECTRONICS N.V.

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for International preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA"). However, this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notifed the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of three months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA:

European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0 Tx: 523656 epmu d
Fax: +49 89 2399 - 4465

Authorized Officer

Gröger, A

Telephone No. +49 89 2399-5251

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This opinion has been established on the basis of a translation from the original language into the following language , which is the language of a translation furnished for the purposes of international search (under Rules 12.3 and 23.1(b)).

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ in written format

   ☐ in computer readable form

   c. time of filing/furnishing:

   ☐ contained in the international application as filed.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	2,4,5,6,7,8,10,15
	No:	Claims	1,3,9,14
Inventive step (IS)	Yes:	Claims	4,5,6,7
	No:	Claims	2,8,10,15
Industrial applicability (IA)	Yes:	Claims	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15.
	No:	Claims	

2. Citations and explanations

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Reference is made to the following documents:
D1: US 5 789 758
D2: US 5 933 365
D3: US 2003 / 0142578 A1

Re Item V
Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1.1 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claims 1, 11, 12, 13 is not new in the sense of Article 33(2) PCT.

A device 90 as disclosed by D1, Fig. 2, comprises: a resistor comprising a layer 75 of phase change material (D1, col. 4, l. 59-col. 5, l. 40). The composition of the phase change material is defined by D1, col. 5, l. 1-7 by the general formula $Te_aGe_bSb_{100-(a+b)}$ with $a \leq 70\% = 0.7$ and $15\%=0.15 \leq b \leq 50\%=0.5$. The case $a=0$ and $b=0.4$ corresponds to the case M=Ge and c=0.4 as defined by claim 11 of the present application. The composition resulting by setting $a=0$ and $b= 0.4$ fulfills also the criteria as defined by claims 12 and 13 of the present application. For this reason, this composition is a phase change material being changeable between a first phase with a first electrical resistivity and second phase with a second electrical resistivity different from the first electrical resistivity, the phase change material being a fast growth material, the resistor being switchable between at least three different resistance values by changing a corresponding portion of the payer of the phase change material from the first to the second phase, as defined by claim 1 of the present application.

Other compositions as defined by D1, col. 5, l. 1-7 also fulfill the criteria as defined by at least some of claims 11, 12, and 13 of the present application and therefore are also materials with the properties in the sense of claim 1 of the present application.

Therefore, the subject-matter of claims 1, 11, 12, and 13 of the present application is

anticipated by D1.

1.2 Furthermore, the present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 1 is not new in the sense of Article 33(2) PCT.

Document D2, Fig. 1a discloses a device having a resistor comprising a layer of phase changing material 36 being changeable between a first phase with a first electrical resistivity and a second phase with a second electrical resistivity different from the first electrical resistivity (D2, col. 5, l. 45-65). The layer 36 consists of a fast-growth material in the sense that the materials used by D2 are specifically selected to improve the switching time of the device, cf. D2, col. 2, l. 1-8, col. 6, l. 14-18. It is clear from D2, col. 18, l. 1-11 that the resistor is switchable between at least three different electrical resistance values by changing a corresponding portion of the layer of the phase change material from the first phase to the second phase.

Therefore, the subject-matter of claim 1 of the present application is also anticipated by D2.

2. Dependent claims 3, 9, and 14 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty, the reasons being as follows:

2.1 **Claim 3:**
In the device of D2, Fig. 1a, the heating layer 38 is a further resistor in direct contact with the portion of the layer arranged in parallel with the portion of phase change material 36 in the sense defined by claim 1 of the present application. Layer 38 is arranged in parallel to layer 36 in the geometrical sense of the term.

2.2 **Claim 9:**
In the device of D1, Fig. 2, the phase change material 75 constitutes a conducting path between contact areas between 85 and 75 on the one hand and 65 and 75 on the other. It can be seen in D1, Fig. 2 that the total cross-section of the conducting path defined by the pore 70 is smaller than the respective cross-sections of contact

layer 65 and 85. The same applies for the device of D2, Fig. 1a, with phase change material 36 and contact layers 32, 34 on the one hand and 38, 40 on the other hand, with the cross-section of the path being determined by the opening in dielectric layer 46.

2.3 **Claim 14:**
The device as disclosed in D1, Fig. 5 comprises an array of memory cells comprising a memory element 90, a respective selection device 50, a grid of selection lines 15, 100 with each memory cell being individually accessible via the respective selection lines connected to the respective selection device. This applies also to the arrangement of D2, Fig. 3, with selection lines 12, 42, selection devices 26 and memory elements 30.

3. Dependent claims 2, 8, 10, 15 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of inventive step, the reasons being as follows:

3.1 **Claim 2:**
Since the possibility of storing multiple bits in a single cell is explicitly mentioned by D1, col. 1, l. 41-58, the skilled person would integrate such switching means with the addressing matrix D1, Fig. 6, 215. The same applies for the passage D2, col. 18, l. 1-11 and D2, Fig. 4, 52 mutatis mutandis.

3.2 **Claim 8:**
The claimed range appears to be an arbitrary selection.

3.3 **Claim 10:**
In constructung the device of D1, the skilled person would consider minimising the contact resistance as part of a standard design procdure, thus obtaining the subject-matter of claim 10 of the present application without an inventive activity.

3.4 **Claim 15:**
A metal oxide field effect transistor as selection means is a standard measure in the

art and constitutes an obvious replacement for the diodes disclosed in D1 which the skilled person would select to meet operational or manufacturing requirements. The same applies for the diode selection elements 26 of D2 mutatis mutandis.

4. It appears at this moment that the subject-matter of claims 4, 5, 6, and 7 may serve as the basis for a new, allowable set of claims.

The device as defined by claims 4, 5, 6, and 7 of the present application differs from the device of D1, which is considered to be closest prior art, in the presence of the additional resistance 6 and the defined resistance ranges. The technical effect of this additional resistance is a compression of the total scale of resistances to be detected when using the device as a multi-state resistance memory. In particular, this has the advantage of a more reliable distinction of different resistance states under conditions of non-constant temperature since it minimises the influence of the strong - typically exponential - temperature dependence of the absolute resistance values of the chalcogenide material.

This solution is not disclosed by the available prior art.

None of the prior art documents does even mention the problem, therefore, the skilled person does not have any indication for the solution of the present application.

The device of D2 has the additional resistance layer arranged in parallel in the geometrical sense of the term, not in the electrical sense of "parallel". Therefore, also this configuration does not indicate any hint to resistance ranges as defined by the present application, since the configuration of the device of D2 is not suitable for such a circuitry and procedure.

The skilled person might also consider combining the teachings of D1 and D3 in order to obtain a device in a simplified geometry compared to D1. The result would be a device with a continuous layer of chalcogenide material instead of the ceramic material layer D3, Fig. 1, 16. In this case, the bulk resistance D3, Fig. 3, 54 and D3, [0022] would be arranged in parallel to the portion were the phase of the material is

changed. However, the wording of claims 5, 6, and 7 of the present application, incorporating the wording of the claims referred to by claims 5, 6, and 7, implies that the "additional resistor" is well distinct from the "layer of phase change material", which would not be the case in the device that would result from the combination of the teachings of D1 and D3.

Re Item VIII

Certain observations on the international application (clarity).

Claim 1: The term "fast growth material" does not have a well-defined meaning in the general language of the art. It should be replaced, based on the description, by a definition of the materials for which protection is sought in terms of the material composition. It appears that for example p. 19, l. 27-p. 22, l. 7 might serve as a base for such a definition, cf. PCT/GL/ISPE/1 5.20.

Claim 10: The claim refers to claim 5 and uses the term "the conductive path" which is not anticipated by claim 5 or any claim referred by claim 5. Since claim 9 defines such a term in a way that is meaningful for claim 10, it is assumed that claim 10 refers to claim 9 instead of claim 5.

Claim 12: The claim refers to claim 8 and a parameter c. However, there is no parameter c defined in claim 8. Since claim 11 defines a parameter c that appears to be meaningful in the context of claim 12, it is preliminarily assumed that claim 12 refers to claim 11.

Claim 13: The term "substantially free of Te" does not allow a precise determination of the interval to be defined by the claim, cf. PCT/GL/ISPE/1 5.38.

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International Patent Classification (IPC) or both national classification and IPC
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Applicant
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- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
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For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA:

European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0 Tx: 523656 epmu d
Fax: +49 89 2399 - 4465

Authorized Officer

Gröger, A

Telephone No. +49 89 2399-5251

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This opinion has been established on the basis of a translation from the original language into the following language , which is the language of a translation furnished for the purposes of international search (under Rules 12.3 and 23.1(b)).

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

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   c. time of filing/furnishing:

   ☐ contained in the international application as filed.

   ☐ filed together with the international application in computer readable form.

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3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	2,4,5,6,7,8,10,15
	No:	Claims	1,3,9,14
Inventive step (IS)	Yes:	Claims	4,5,6,7
	No:	Claims	2,8,10,15
Industrial applicability (IA)	Yes:	Claims	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15.
	No:	Claims	

2. Citations and explanations

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Reference is made to the following documents:
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D2: US 5 933 365
D3: US 2003 / 0142578 A1

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1.1 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claims 1, 11, 12, 13 is not new in the sense of Article 33(2) PCT.

A device 90 as disclosed by D1, Fig. 2, comprises: a resistor comprising a layer 75 of phase change material (D1, col. 4, l. 59-col. 5, l. 40). The composition of the phase change material is defined by D1, col. 5, l. 1-7 by the general formula $Te_aGe_bSb_{100-(a+b)}$ with $a \leq 70\% = 0.7$ and $15\%=0.15 \leq b \leq 50\%=0.5$. The case $a=0$ and $b=0.4$ corresponds to the case M=Ge and c=0.4 as defined by claim 11 of the present application. The composition resulting by setting $a=0$ and $b= 0.4$ fulfills also the criteria as defined by claims 12 and 13 of the present application. For this reason, this composition is a phase change material being changeable between a first phase with a first electrical resistivity and second phase with a second electrical resistivity different from the first electrical resistivity, the phase change material being a fast growth material, the resistor being switchable between at least three different resistance values by changing a corresponding portion of the payer of the phase change material from the first to the second phase, as defined by claim 1 of the present application.

Other compositions as defined by D1, col. 5, l. 1-7 also fulfill the criteria as defined by at least some of claims 11, 12, and 13 of the present application and therefore are also materials with the properties in the sense of claim 1 of the present application.

Therefore, the subject-matter of claims 1, 11, 12, and 13 of the present application is

anticipated by D1.

1.2 Furthermore, the present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 1 is not new in the sense of Article 33(2) PCT.

Document D2, Fig. 1a discloses a device having a resistor comprising a layer of phase changing material 36 being changeable between a first phase with a first electrical resistivity and a second phase with a second electrical resistivity different from the first electrical resistivity (D2, col. 5, l. 45-65). The layer 36 consists of a fast-growth material in the sense that the materials used by D2 are specifically selected to improve the switching time of the device, cf. D2, col. 2, l. 1-8, col. 6, l. 14-18. It is clear from D2, col. 18, l. 1-11 that the resistor is switchable between at least three different electrical resistance values by changing a corresponding portion of the layer of the phase change material from the first phase to the second phase.

Therefore, the subject-matter of claim 1 of the present application is also anticipated by D2.

2. Dependent claims 3, 9, and 14 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty, the reasons being as follows:

2.1 **Claim 3:**
In the device of D2, Fig. 1a, the heating layer 38 is a further resistor in direct contact with the portion of the layer arranged in parallel with the portion of phase change material 36 in the sense defined by claim 1 of the present application. Layer 38 is arranged in parallel to layer 36 in the geometrical sense of the term.

2.2 **Claim 9:**
In the device of D1, Fig. 2, the phase change material 75 constitutes a conducting path between contact areas between 85 and 75 on the one hand and 65 and 75 on the other. It can be seen in D1, Fig. 2 that the total cross-section of the conducting path defined by the pore 70 is smaller than the respective cross-sections of contact

layer 65 and 85. The same applies for the device of D2, Fig. 1a, with phase change material 36 and contact layers 32, 34 on the one hand and 38, 40 on the other hand, with the cross-section of the path being determined by the opening in dielectric layer 46.

2.3 **Claim 14:**
The device as disclosed in D1, Fig. 5 comprises an array of memory cells comprising a memory element 90, a respective selection device 50, a grid of selection lines 15, 100 with each memory cell being individually accessible via the respective selection lines connected to the respective selection device. This applies also to the arrangement of D2, Fig. 3, with selection lines 12, 42, selection devices 26 and memory elements 30.

3. Dependent claims 2, 8, 10, 15 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of inventive step, the reasons being as follows:

3.1 **Claim 2:**
Since the possibility of storing multiple bits in a single cell is explicitly mentioned by D1, col. 1, l. 41-58, the skilled person would integrate such switching means with the addressing matrix D1, Fig. 6, 215. The same applies for the passage D2, col. 18, l. 1-11 and D2, Fig. 4, 52 mutatis mutandis.

3.2 **Claim 8:**
The claimed range appears to be an arbitrary selection.

3.3 **Claim 10:**
In constructung the device of D1, the skilled person would consider minimising the contact resistance as part of a standard design procdure, thus obtaining the subject-matter of claim 10 of the present application without an inventive activity.

3.4 **Claim 15:**
A metal oxide field effect transistor as selection means is a standard measure in the

art and constitutes an obvious replacement for the diodes disclosed in D1 which the skilled person would select to meet operational or manufacturing requirements. The same applies for the diode selection elements 26 of D2 mutatis mutandis.

4. It appears at this moment that the subject-matter of claims 4, 5, 6, and 7 may serve as the basis for a new, allowable set of claims.

The device as defined by claims 4, 5, 6, and 7 of the present application differs from the device of D1, which is considered to be closest prior art, in the presence of the additional resistance 6 and the defined resistance ranges. The technical effect of this additional resistance is a compression of the total scale of resistances to be detected when using the device as a multi-state resistance memory. In particular, this has the advantage of a more reliable distinction of different resistance states under conditions of non-constant temperature since it minimises the influence of the strong - typically exponential - temperature dependence of the absolute resistance values of the chalcogenide material.

This solution is not disclosed by the available prior art.

None of the prior art documents does even mention the problem, therefore, the skilled person does not have any indication for the solution of the present application.

The device of D2 has the additional resistance layer arranged in parallel in the geometrical sense of the term, not in the electrical sense of "parallel". Therefore, also this configuration does not indicate any hint to resistance ranges as defined by the present application, since the configuration of the device of D2 is not suitable for such a circuitry and procedure.

The skilled person might also consider combining the teachings of D1 and D3 in order to obtain a device in a simplified geometry compared to D1. The result would be a device with a continuous layer of chalcogenide material instead of the ceramic material layer D3, Fig. 1, 16. In this case, the bulk resistance D3, Fig. 3, 54 and D3, [0022] would be arranged in parallel to the portion were the phase of the material is

changed. However, the wording of claims 5, 6, and 7 of the present application, incorporating the wording of the claims referred to by claims 5, 6, and 7, implies that the "additional resistor" is well distinct from the "layer of phase change material", which would not be the case in the device that would result from the combination of the teachings of D1 and D3.

Re Item VIII

Certain observations on the international application (clarity).

Claim 1: The term "fast growth material" does not have a well-defined meaning in the general language of the art. It should be replaced, based on the description, by a definition of the materials for which protection is sought in terms of the material composition. It appears that for example p. 19, l. 27-p. 22, l. 7 might serve as a base for such a definition, cf. PCT/GL/ISPE/1 5.20.

Claim 10: The claim refers to claim 5 and uses the term "the conductive path" which is not anticipated by claim 5 or any claim referred by claim 5. Since claim 9 defines such a term in a way that is meaningful for claim 10, it is assumed that claim 10 refers to claim 9 instead of claim 5.

Claim 12: The claim refers to claim 8 and a parameter c. However, there is no parameter c defined in claim 8. Since claim 11 defines a parameter c that appears to be meaningful in the context of claim 12, it is preliminarily assumed that claim 12 refers to claim 11.

Claim 13: The term "substantially free of Te" does not allow a precise determination of the interval to be defined by the claim, cf. PCT/GL/ISPE/1 5.38.